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DIVISION OF RESEARCH RESOURCES
BIOTECHNOLOGY RESOURCES BRANCH
RESOURCE IDENTIFICATION

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Name of Resource	Resource Address	Resource Telephone No.
Advanced Computer for Medical Research (ACME)	Stanford University School of Medicine Stanford, California 94305	(415) 321-1200 Ext. 6121
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Grantee Institution	**Type of Institution**	**Investigator's Telephone No.**
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Name of Institution's Biotechnology Resource Advisory Committee:

ACME Policy Committee

Membership of Biotechnology Resource Advisory Committee:

Name	Title	Department	Institution
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I. SUMMARY

A. Brief Evaluation.

The ACME facility is now approaching the end of a six-year grant plus a one-year administrative extension. The ACME experiment has proven highly successful as demonstrated by the following points:

1. Teachability:

Medical researchers have been taught to do their own programming for non-trivial tasks. More than 1700 persons on the Stanford medical scene have been trained in the use of computers.

2. Strong Educational Tool:

This facet of ACME encourages many persons to become involved in computing.

3. Data Acquisition:

The ACME system combines moderate rate data acquisition service with timesharing. A relatively sophisticated group of realtime data acquisition users has been developed.

4. User Community:

More than 210 user projects, exclusive of ACME staff, are current users of the system. They enter the system from 55 terminals spread throughout the Medical Center.

5. Programming Effort:

The ACME disk packs and tapes hold programs representing over 250 man years of programming effort.

6. Publications:

A list of recent publications by ACME users and an index of ACME Notes prepared by ACME staff are presented in Section VIII.

7. Dedicated Systems:

Several groups are now using dedicated computer systems which reflect an outgrowth of pilot projects performed on the ACME facility. We observe a propensity of large or clinical projects to become autonomous from large central facilities.

The ACME experiment was initiated nearly seven years ago to provide a timesharing system on an IBM 360 hardware system concurrent with some realtime data handling. Applying hindsight to the choices made we can now see that our successes noted above are mitigated by some trends which were not predicted by us in 1965. Specifically, technological and price/performance changes have occurred since 1965 which make mini-computing systems dedicated to specific tasks much more competitive with centralized resources than was true in 1965. Based upon our experiences, we at Stanford Medical Center are moving to establish an improved large central computing system while, at the same time, the number of dedicated mini-systems is steadily increasing. In other words, the clear advantages of a large central system for certain applications are offset by other goals in a number of realtime and control situations where dedicated mini-systems offer the only realistic solution.

Some of the more significant changes over the past seven years have included the following:

(1) Both logic and, somewhat later, main memory units have dropped in cost by 1 to 2 orders of magnitude for devices of roughly equal performance.

(2) Disk systems have increased in capacity, speed of access, and reliability while costs have dropped markedly. The figures below demonstrate this trend.

Hardware Devices	Speed	Capacity	MByte/Month
1. Core or semiconductor	200×10^{-9}	8MB	$5,000
2. Fixed Head	2 to 5 $\times 10^{-3}$	22MB	$500-1,000
3. Moving Head	26 to 30 $\times 10^{-3}$	800MB	< $10

DISK PERFORMANCE DATA FOR IBM HARDWARE*

Item	1956	1966	1970	1973	Est. 1977-80
1. Capacity	5	233	800	800+	3 x 800
2. Bits/Inch	100	2200	4040	5600	4 x 5600
3. Tracks/Inch	20	100	192	300	600 to 900
4. RPM	1200	2400	3600	3000	
5. Data Rate	9.7KB	312	806	885	4 to 10 x 885
6. Disk Coating in micro inches	1000	100	50	50	
7. Flying Height in micro inches	1200	100	50	50	
8. Gap Width	1000	100	50	50	

* Data received in IBM presentation in San Jose, California held in May, 1973.

(3) The prices for mini-computers have dropped an order of magnitude while capability and level of software support have increased significantly. Also, the variety and flexibility of adding various peripherial devices has risen sharply.

(4) Communications terminals and supporting equipment has improved in terms of speed and reliability.

(5) The user community has grown in numbers and level of sophistication. It also demands increased availability and reliability. Response times must now be measured in fractions of seconds rather than seconds which imposes high overhead costs on large time shared systems.

In 1965 a handful of computer users existed in the Medical Center. Today, there are more than 200 active research projects on the ACME system plus about 25 mini-systems in laboratories. Computers have become accepted for production use in many applications.

The first year and a half of the ACME grant was spent assembling staff and hardware and developing the PL/ACME system. The result was one of the first timesharing systems with concurrent realtime support. The system we mounted is remarkedly easy to learn and use. Since the system has not been exported, we assume that a shift back to the mainstream of software systems as provided by vendors will become necessary. The relative cost of people versus hardware has grown to a point where " home brew" systems cannot be afforded over the long term. This situation is regretted since many of the newly announced systems fail to deliver to the end-user the convenience and power of our existing system. At Stanford, the conversion to vendor-supplied systems might be expected to occur in three or four years.

The series of developments in mini-systems has relieved some burdens but created new needs for small machine support from a central system. Stanford expects to expand upon the currently available intercommunication systems. Since mini-systems are frequently being used as data collection controllers, the development of shared data base systems on the central machine requires inter-machine communication capability.

We have offered graphics services on the ACME system over the past five years. There are now six graphics CRT's plus five hard copy plotters attached to the ACME system. The growth in graphics usage has been slower than one might have expected. We suspect that this reflects a lack of description tools, the relatively high cost of graphics terminals, plus the high cost of running graphics software. Perhaps, the growth spurt will come in a few years after the costs are dropped another factor of 5 or so, and description tools are improved.

Our dependency upon NIH in establishing a user community and developing a financial base with which to support computing services warrants special mention. It is clear to me that the venture capital to establish a system, train users, and form a critical mass of support could not have been raised by incremental growth through charges to individual research grants. A central facility development grant, such as ACME grant, is the only available counterpart to venture capital in a cash-accounted grants system. This investment has now paid off: We have a common language in use by nearly every department in the Medical School, a cadre of trained programmers, and a strong momentum in the direction of shared data bases and shared programs. Some continuing incremental development effort will be needed to prevent atrophy.

The passage of time has brought about needs for realtime support systems which exceed the capabilities of our local ACME system by one or two orders of magnitude. Rather than attempt to build realtime systems which IBM hardware has not been designed to perform, we prefer to rely on alternative systems specifically designed for this use and build improved communications into the central site. Further efforts will therefore constitute another generation of system planning, based on vendor-furnished modules.

We have all heard of TSS, TSC, TORTOS, CPS, CMS, and other timesharing systems built on IBM hardware systems. It is a credit to the small staff which built PL/ACME that their system can compare so favorably with the other systems which have clearly had far more effort spent on development. The use of PL/ACME as a research tool by so many local groups is a tribute to the system designers and implementers. Gio Wiederhold deserves special credit as the principal creator of the system. He would also be the first to point out some of the design features that might have been improved with the benefit of hindsight. The lists of publications and technical notes appended to this report attest to the productivity of the ACME Facility staff and to the effectiveness of the tools provided to the user community.

J. Lederberg

B. Highlights of FY73.

1. Planning for the Future.

During the past twelve months the ACME computing facility has passed through an identity and existence crisis. The sizeable effort expended by faculty, Hospital staff, and ACME facility staff has led to a decision to maintain the PL/ACME system on new hardware. The computer services for Hospital administration and ACME time sharing and realtime data acquisition services are being merged onto a new facility to be installed in August 1973. Numerous studies and presentations have been required to bring about the decisions which make this possible. This subject is discussed in detail in Part C of this section and in Section II.

2. A Generalized Time Oriented Database System.

Special attention should be focused on the transition which has begun to occur at Stanford with respect to faculty attitude toward the need for sharing of data. The awareness of shared database concepts has increased markedly. Evidence of this can be seen in the teamwork demonstrated in preparation of a health care resources research proposal. Other evidence can be seen in the attendance at seminars concerning the Time Oriented Database system (TOD), developed this year by the ACME staff in conjunction with Dr. James Fries of the Division of Immunology. For more on this subject, see Section V.

3. Software.

System programming development activities during the year resulted in new data compression routines, file system improvements, mounting the COBOL compiler, studies and planning concerning the new VS2 system announced by IBM, support for the small machine multiplexor, and a PDP-11 simulator.

4. Hardware.

The small machine multiplexor was completed, allowing for inter-machine communications. Other hardware projects included work on terminal lightboxes and several new interfaces for users of the 1800 and the multiplexor. ACME acquired several 300 and 1200 baud terminals during the year. In April 1972, we installed a Memorex terminal controller which has performed very well.

5. Core Research.

Support of core research and development effort included programming and computer service support for the DENDRAL project, assistance for the Drug Interaction project, direct support of the initial application of the Time Oriented Data (TOD) system, extension of small machine support to GC/MS activity, a joint development effort on communication hardware development, and a core project to develop new statistical analysis techniques.

6. Utilization.

Utilization of the ACME system in terms of terminal hours has remained relatively constant during the past year. One exception to this is the Drug Interaction project in the Pharmacy which used ACME extensively through February 1973, after which time the system was moved to a dedicated dual mini-computer system.

Since the follow-on to the ACME system was not resolved until March 1973, the rate of new user signups has dropped from normal levels and there have been essentially no new realtime users of the system. This is most understandable since many users felt that ACME might not survive beyond the end of the grant period. It is noteworthy that the user community has continued to use the system in the absence of (prior to March 1973) any Medical Center commitment to retain the PL/ACME system beyond July. Now that such assurance has been made, new users are again expressing interest, evidenced by the number of signups for the introductory classes in use of PL/ACME.

7. Minicomputers.

Other computing activity in the Medical Center includes the acquisition of several minicomputer systems for various research and production projects. Approximately thirty minicomputer systems are currently used within the Medical Center. Some of the applications include data acquisition for mass spectrometers, operation of the Drug Interaction programs, an information system for the Clinical Laboratories, and research support in Nuclear Medicine, Chemistry, Psychiatry, Cardiovascular Surgery, Cardiology, and other divisions and departments. The growth and number of minicomputer systems used for instrumentation control and data collection have pushed the central facility to provide small machine communications and other support activities.

8. Documentation & Conversion.

Throughout Fiscal 73, the staff has spent a great deal of time on documentation of the existing ACME system. Since the decision to move to a merged/158 facility, the conversion effort has been of central importance.

C. Planning and Reorganization.

1. Stanford Center for Information Processing (SCIP).

In the past Stanford operated five major service computing organizations, each of which had its own loyalties to a specific user community. The five were:

Stanford Linear Accelerator Center
University Administrative Computing Facility
Campus Facility
ACME Facility
Hospital Data Processing Facility

Computing at Stanford University was reorganized during the spring of 1973. The new organization, entitled "Stanford Center for Information Processing (SCIP)", provides a unified structure for the five facilities mentioned above. ACME and the Hospital Data Processing Facility will be combined to form the Medical Center Computing Service (MCCS). The heads of all the facilities will report to the director of SCIP. Along with the reorganization of staff involved in managing the various computer facilities, the policy committee structure comprised of faculty members is currently being modified.

2. The Medical Center Planning Effort.

A description of the computer planning activity at the Stanford Medical Center over the past eighteen months would fill many volumes. Several different faculty committees and staff groups have reviewed alternatives ranging from highly distributed interconnected minicomputer systems to highly centralized large computing systems. The issues faced by the various groups were:

1. Should PL/ACME service be continued?

2. Can the ACME users provide a critical mass of dollars required for a stand-alone facility.

3. If a merger is required, who should be the parties to the merger?

4. Are the potential advantages of a shared database between Hospital and Medical School strong enough to outweigh the disadvantages of merging a production system with a research support system?

5. Should realtime computing services continue to be provided from a central computing source?

6. How should computing at Stanford University and the Medical Center in particular be organized?

7. What computing services will be needed over the next several years?

8. How can we relate Medical Center computing planning to broad University goals?

3. The 370/158.

These are among the many issues which have been considered during the past year and a half. The solution selected entails the installation of an IBM 370/158 hardware system using IBM's newly announced VS2 software system. The services to be offered will include batch services in several languages, time-sharing using PL/ACME, realtime data acquisition services using the existing 1800 system, normal consulting and user services, and small machine communications.

The current schedule calls for removal of the 360/50 system from Stanford on July 28, 1973. A number of peripherals will be moved to the new 370/158 site where systems programmers will have approximately 2-1/2 to 4 weeks to bring up the new system. We expect to resume PL/ACME services for terminal users by September 1, 1973; realtime services will hopefully be available approximately one month later.

Funding for use of computers within the Stanford Medical Center is expected to drop over the next eighteen months due to cuts in federal budgets as well as escalation of costs within fixed budgets. A tight dollar economy coupled with multiple options for the users (e.g. outside time sharing service, Campus computing facility, more powerful dedicated mini systems) will force the new Medical Center Computing Service to perform very well to attract the business of the Medical Center commuity.

4. The SUMEX Proposal.

A proposal has been submitted by Dr. Lederberg calling for the formation of a Stanford University Medical Experimental Computing Facility (SUMEX). If approved, this proposal would result in the acquisition of a PDP-10 to support a national facility specializing in tools for the development of artificial intelligence in medicine (AIM). The ACME experience has been invaluable in demonstrating both the opportunities and the problems of community-shared resources. In particular it has given us the technical expertise needed to design realistic specialized instruments to serve geographically dispersed but intellectually convergent users.

D. Overview of ACME Experiment.

The ACME experience indicates that a large central resource can provide a very valuable service for users requiring text editing, numeric calculations, statistical analyses, and realtime data acquisition at relatively low rates. Our experience has also demonstrated that a large central facility should not undertake high data rate realtime data acquisition and closed loop control functions if it intends to service a large number of time sharing users concurrently. In addition we have learned that an extensive amount of "hand-holding" is needed to serve the research scientists in a medical community. This may change in the future when MD's will routinely receive more training in computer science in the course of their college educations.

ACME's initial proposal included the following paragraph concerning hardware selection and resource allocation:

> "The IBM/360-50 has been selected for the initial realization of ACME (1) as a machine technically appropriate to the immediate tasks in mind and (2) for its system compatibility with the 360-67 already selected for the eventual replacement of the 7090 by the Stanford Computation Center. The 360-50 will be installed in ACME May 1966 and will run on three shifts under Operating System/360, subject to review by the policy committee. These will be dedicated respectively:

(A) A prompt access time-sharing mode - perhaps over most of the working day.

(B) A scheduled, full-use, on line mode - to service development work on high data rate and on line control applications, and for similar systems development.

(C) Job-shop, especially longer runs for which overnight turnaround is acceptable, and which cannot be serviced with comparable effectiveness by SCC."

The following aims were added to the ACME charter at the time of the Renewal Proposal in the Spring of 1969:

1. To improve hardware and software reliability for the benefit of the medical users.

2. To provide small machine assemblers in PL/ACME so that code for small machines can be written from an ACME terminal.

3. To achieve over time a state where income from user charges will match operational costs for the ACME system.

All of the original objectives have been achieved to varying degrees of satisfaction. Of special note is the development of PL/ACME as an interactive time sharing system which can be easily learned and used by medical staff. On the other hand, the realtime support offered is inadequate due to system instabilities and data rate limitations. Access to Campus Facility is inconvenient for ACME users.

In terms of the items added at renewal time, hardware and software reliability have been markedly improved. Small machine assemblers have been added, but the user must write code in the assembly code for whatever satellite he intends to run. At present, assemblers of this type exist for PDP-11, PDP-8, and 1800. The income of the facility has been rising steadily. Economic overlaps with NIH direct support for ACME have blurred the transition to totally non-subsidized use. A major rate increase was initiated in April, 1972. With this change, income over the last 12 months reached roughly 55% of direct operating costs (exclusive of development efforts). From the vantage point of hindsight one could well ask whether the selection of the 360/50 hardware and the decision to promote a large central time sharing and data collection resource were appropriate. Given the availability of new third generation hardware and the promises of IBM or expectations of its customers in 1966, the 360/50 hardware selection is defensible. However, the development of low cost, fast, well-supported minicomputers was not anticipated to proceed at the phenomenal pace that it has. This major technological shift has strongly influenced our present thinking for the future of computing in medicine and related research. The role of a large shared resource has by no means been obviated by the minicomputer revolution. We will continue to need powerful facilities beyond the scene of current mini architecture.

II. STANFORD MEDICAL CENTER COMPUTING PLANS

A. The Current Scene.

Between January and April 1973, the following significant events occurred in the computing environment affecting the Medical Center:

1. The University reorganized the service computing management structure to form the Stanford Center for Information Processing (SCIP). The SCIP organization will manage and operate all major service computing functions for the University.

2. The Board of Trustees authorized acquisition of an IBM 370/158 system to service the needs of the Medical Center.

3. Personnel from the ACME Facility and Hospital Data Processing Facility were assigned the task of converting the current systems to the new hardware systems.

4. Users were notified of the changes scheduled to occur between July and December 1973.

5. Planning of new faculty advisory groups for computing throughout Stanford was done.

PL/ACME users had been warned that the time sharing service might have to be disbanded at the close of the ACME grant. Therefore, the ACME community was elated by the above series of decisions. Medical School faculty and Hospital management were notified of the scheduled changes by a memorandum from Mr. Victor Barber dated April 23, 1973. A copy of this memorandum has been reproduced on the pages which follow.

B. Shared Database Planning.

The need for planning of shared database effort is presented in Appendix A. Given the need to which these memoranda attest, it is likely that the central facility will assign key personnel to work on the problem along with interested researchers. The near term development effort is likely to be based on use of the Time Oriented Database (TOD) system. Further information on TOD is presented in Section V of this report.

C. New Faculty Appointment.

A selection committee has nearly completed its deliberations with respect to a new faculty member in the Medical School who will have considerable responsibility for policies affecting computer services. The new position will be located in the Department of Community and Preventive Medicine. It is hoped that the new appointee will serve as a focus and spearhead for development activity in the shared database area.

DATE: April 23, 1973

TO: Distribution

V. H. Barber

FROM: V. H. Barber, Associate Director, Medical Center Computing Service
Stanford Center for Information Processing

SUBJECT: Computing Services for Medical Center

Stanford University announced in March of 1973 the complete reorganization of its general support computing facilities. The new organization, Stanford Center for Information Processing (SCIP), is described in the attached press release. The result of the reorganization provides a large general support computing facility in the Medical Center environment that merges the services of the medical research community with the business, administrative, and patient care activities.

My role as Associate Director of the Medical Center Computing Service is to serve Medical Center users and represent their interests in the service computing arena. Our goal will be to provide the required computing services at the lowest possible cost. A new hardware system will be available to serve the entire Medical Center in September 1973. The new facility will have more than three times the compute power of existing service facilities and will make available improved services during the year as the power of the system is harnessed with associated software. These will include shorter response or turn-around time and sharing of data bases.

A list of service goals for the MCCS is attached as Appendix A. Additional needs of the medical community will be established through interaction with the Hospital management group, individual users, and faculty committees.

We intend to provide easy communications between you, the user, and the staff of the new facility. We want a highly personalized service that is responsive to the needs of the medical community. Madhu Bhide,x5151, will be the primary liaison and coordination point for Hospital services, especially those oriented toward financial applications. Ms. Karen Richards, R.N., will continue as the Nursing Service Coordinator for computing matters. She is available at x6084. Ron Jamtgaard, x6121, will be the primary contact for users of timesharing services and realtime support; he will respond to needs of the Medical School research and education functions. B. J. Gaul will be Operations Manager of the 370/158 computing facility. He is available at x5880.

Ron Jamtgaard and his staff will be housed in the old ACME offices (TC101, temporary building). All other MCCS computing and management personnel will be located in the Administrative Services Annex, just north of the Medical Center, in the old Hospital Data Processing area.

We plan to serve you in the following manner: The new hardware facility (IBM 370/158) will be available in September 1973 to serve the reasearch and development interests of the Medical Center; by December 1973, the business and finance computing will be merged onto the new system. The services which will be offered when the facility opens include timesharing (using the PL/ACME language) and batch services in those languages for which a user need exists. Initially, batch services will be provided for FORTRAN, COBOL, PL/1, and LISP. Services to the business and finance community will continue as before; however, larger resources will be available, and there will be new opportunities for service.

The transition from PL/ACME on the current Model 50 to the 370/158 will be transparent for the terminal user except possibly in some realtime areas. Our target is to hold service interruption times to a minimum. Standard terminal services will likely be unavailable for about four weeks; realtime services may be disrupted for six to ten weeks. Digital realtime data acquisition services and graphics via the IBM 1800 as well as small machine communications will be provided by the new facility as soon as possible. The transition of Hospital services should be completed by December 1973.

The facility will be operated on income received through user fees. Our goal will be to provide maximum service at the most cost effective rates. Further policy on fees will be developed and released in the near future.

Persons who are new to the Stanford medical computing scene are encouraged to contact me at x5998 so that staff can be assigned to assist in definition and solution of computing needs.

MCCS exists to serve you and your computing needs. We hope to hear from many of you regularly.

cc: Medical School Faculty
Hospital Department Heads
ACME Users
SCIP Associate Director
C. Rich
P. Carpenter
T. Gonda
P. Hofmann
C. Dickens
M. Roberts
R. Jamtgaard

MEDICAL CENTER COMPUTING SERVICE

FUNCTIONS, SERVICES, AND GOALS

1. Patient Accounting. Hospital financial and administrative services and patient accounting services. These services involve chiefly patient accounting, patient billing for Stanford Hospital and Clinics, accounts receivable, third-party allocations, payroll, personnel, general ledger, accounts payable, census, financial and budgetary analyses for the Stanford University Hospital.

   As part of the patient accounting services, MCCS manages a large patient financial data base. It is expected that this will form a nucleus for a comprehensive patient data base in the future. One of the services that the service facility will offer is building on and managing this patient data base for both the Hospital administrative staff and medical research personnel interested in the patient data base.

2. Interactive time-sharing -- PL/ACME. PL/ACME is an easy-to-use time-sharing service. The major user of this service is the medical community at Stanford University. It is expected that the proposed facility will continue to support PL/ACME in its present form and gradually enhance the service to satisfy future requirements.

3. Data reduction and data control services. Currently a well-trained staff of keyboard operators and data control personnel perform these services for the Stanford University Hospital. This service will continue to be performed, and the recipients of this service will expand from Hospital financial data processing users to include other medical personnel.

4. Realtime services. Realtime service is currently provided by an IBM 1800 and ACME-built interfaces in the laboratories. The 1800 is programmed as an integral part of the system and acts as a 360 control unit. These services are currently used routinely by a number of investigators.

5. Small machine communications services. A multiplexor (MUX) for connection of mini-computers to the new 370/158 will be installed in 1973, after more routine services are operational.

6. Data collection. The new facility hopes to collaborate in the development of data collection systems. An example would be the development of an automated Patient Admission, Discharge, and Transfer system. Opportunities in this field will be vigorously pursued.

7. Language support. Other such collaborative efforts are foreseen in the area of language support. One such example is the MUMPS language. This language was developed at the Massachusetts General Hospital. It is used in conjunction with PDP-11 and PDP-15 computers. The Hospital uses a PDP-11 MUMPS system for the Pharmacy Drug Interaction Project. The facility role is not clear; we are open to new ideas here.

8. Liaison with Forms Management. MCCS will work closely with the Hospital Forms Management Section. The responsibility of the Forms Management Section is to coordinate all the forms that are used at the Stanford University Hospital. It takes on the responsibility of designing, printing, ordering, and stocking of forms. This service is expected to continue and will closely interact with the information flow development at the Medical Center.

9. Programming and consulting. The proposed facility will offer programming and consulting service. These programming activities include fee-for-service programming for users, design and development of production systems, and maintenance of public utility programs as well as existing projuction systems. Additionally, the facility will offer services in the areas of procedures analysis and automation of procedures. One of the current analytical services in which we are participating is an automated work-measurement study. It is expected that the proposed facility will continue to participate in such studies and offer services in these areas.

10. Library and grant assistance. Assistance in the identification of funding opportunities, proposal preparation, and management of grants that include the use of computer facilities will be available.

    A library of current reference publications in the area of computer use in the health care field will be maintained.

11. Educational activity. The facility is expected to be very active in continuing its current educational activities, specifically in teaching ACME's interactive and timesharing usage, as well as education of nursing and other Hospital staff in automated procedures. It is further expected that the proposed facility will extend its activities in continuing education of Hospital staff in data processing procedures, systems design, and data base management, and that it will also be active in the area of current awareness and dissemination of information to physicians and other medical personnel. As an adjunct of this, it is expected that the proposed facility will have an internal awareness program to keep its staff abreast of development in health care technology as applied to a computer service facility of a major medical center.

D. Some Observations on Computer Planning.

It took the Medical Center and University eighteen months to perform the planning activity leading to a decision for a course of action. A chronology of this period is attached as Appendix B. By scanning the chronology one can quickly observe that organizational and technical issues involving computing become quite complex and require extended timeframes to complete. Some of the major policy issues addressed by the various study committees included the following:

1. Do we want a highly centralized computing environment or do we choose a distributive minicomputer system with some inter-machine communications? Would some middle ground between these two choices be most appropriate?

2. Can we successfully merge the research support computing of the Medical School with the business and finance data processing of the Hospital?

3. What advantages might be gained by merging with the central Campus Facility of the University?

4. What investment does the PL/ACME user community have in the PL/ACME system and language? How easily could they be converted?

5. How can we fund computing for medical students and researchers on the faculty?

6. What computing needs are likely to dominate over the next five years?

These are some of the questions which the various committees have addressed.

III. ACME FACILITY ACCOMPLISHMENTS - FY73

Accomplishments of ACME staff personnel are described here; core research projects led by faculty members are included in Section V.

The primary accomplishment of the ACME facility during the past year has been to hold its user community largely intact during a period when the future existence of PL/ACME services was highly in doubt. The doubt stemmed from the fact that PL/ACME services had been subsidized by the ACME NIH grant and that the paying users did not constitute a critical mass to afford a facility which could duplicate these services.

A. Planning Studies.

Since October 1971 several members of the ACME staff have been actively involved in planning methods to continue offering PL/ACME services beyond the period of the ACME grant. There follows a list of some of these studies:

1. Merger of Hospital ADP and ACME facilities on a 360/65, PDP-10, or 370/158.

2. Merger of University Administrative Computing Facility, Hospital, and ACME facilities on a 370/158.

3. Merger of Campus Facility and ACME on a 360/67.

4. Conversion effort to mount ACME on various systems.

5. User surveys to determine user plans if PL/ACME services were dropped.

6. Specification of users needs.

7. Review of potential need for time oriented database sub-systems.

8. Consideration of various organizational alternatives. The results of most of these planning studies have been reported in earlier sections of this report.

B. Time Oriented Database Development.

One of the major tasks of the ACME applications staff during FY73 has been the generalization for ACME users of the Time Oriented Database system originally designed by Dr. James Fries of the Division of Immunology. A lengthy description of this system (TOD) is included in Section V of this report.

C. New and Continuing Applications Programs.

1. DENDRAL:

Support for the DENDRAL project during this fiscal year has consisted of machine services both in interactive PL/ACME and batch LISP. Early in the fiscal year an overnight version of batch LISP was mounted so that jobs could be entered from terminals in the daytime and run when the PL/ACME system was not needed. In addition the LISP interactive compiler was markedly improved. The small machine multiplexor and other small machine support has found limited use in the DENDRAL area. In addition the Loma Linda graphic displays have been fully incorporated into the DENDRAL closed loop control problem.

2. Drug Interaction Project.

This has been the year of transition for the Drug Interaction Project from the ACME system to a dedicated dual PDP-11 system. The new software written in MUMPS is now operational. This project has served as a classic example of how a new idea is formulated by faculty, tested under pilot project status on the ACME system, proposed for a research grant, and finally implemented in a production form. Many of the computing applications in the Stanford Medical Center have followed this course of action.

3. Medical Student Admissions.

Programming is now being done to handle medical student admissions needs. The system will assist the Admissions Office in screening applicants and provide administrative support.

4. Time Series Data Analysis.

Last summer ACME helped to support the work of Dr. Will Gersch of the University of Hawaii who used the ACME system to develop an automatic decision procedure to calculate spectral density estimates. The result of this effort is now available to all users in the form of a public program.

5. Radioimmunoassay Programs.

A number of FORTRAN programs written at NIH have been moved to the PL/ACME system to support research in radioimmunoassays.

6. New Realtime Users.

Very few new realtime users were recruited during the past year. This reflects the doubt in the minds of many concerning the future of PL/ACME realtime services. Two projects which were implemented:

Dr. Don Perkel's project involved analog/digital processing of two to four channels of nerve impulses recorded during swimming of the leech. This is a study of nervous control of movement.

The second project, headed by Dr. P. Sokolove was a study of the role of the nervous system in production and maintenance of circadian rhythms (data consisted of nerve spikes and EEG records).

Note: Detailed descriptions of Items 1 and 4 above are presented in Section V.

D. System Software Improvements.

In addition to its considerable planning effort, the systems staff incorporated a number of improvements into the system during 1973. Some of these are listed below:

1. Satellite Machine Support.

The primary effort here involved mounting the small machine multiplexor. This entailed software in the 360/50 as well as small machine code to test the hardware. The new small machine multiplexor can accommodate up to sixteen satellite machines serially passing data to or from ACME (See Appendix C). In addition a PDP-11 simulator was completed. The simulator can be operated in batch or interactively.

2. LISP.

Two tasks were undertaken for LISP users. The first was to mount an overnight LISP batch service to which jobs could be submitted from terminals during the day. The second was to improve the response time of the interactive compiler.

3. File Support.

The primary improvement was a data compression routine which permits users to file their data in a compressed format. For some users, such as those using the time oriented medical record files, this feature permitted a factor of five savings in storage costs. In addition the file system was documented extensively during the last year.

4. Reliability.

A number of bugs were found and fixed. It is a credit to the system staff that we now operate three to four months between system crashes due to software.

5. Other System Tasks.

The number of terminal ports was expanded from 32 to 48. Accounting programs were modified to capture data at hourly intervals. Batch accounting was added to the system. Release 20 of OS was implemented. A COBOL compiler was mounted for batch running. The file system directory was rewritten. A terminal survey was conducted to determine the best terminals for ACME to support in the future. A hardware monitor (called the SUM monitor) was attached to the system by Lee Hundley for a series of system measurements. Special programs were provided for ACME-to-OS dataset conversion.

E. Education and Training.

Over the past six and a half years more than 1700 members of the Stanford Medical community have been trained in the use of PL/ACME. This number includes only those who have enrolled in a formal training class. During the past twelve months, nine introductory classes have been offered with a total enrollment of 84. This is less than the normal annual enrollment, primarily due to the fact that classes were not held during three months of the year when the future of ACME was unresolved. Of the 84 persons enrolled, 23% had a Ph.D. or M.D. degree, another 45% had a Bachelors or Masters degree, and 32% indicated no degree. Two years ago the corresponding percentage of Ph.D. and M.D. participants was 35%. Approximately one-half of those who signed up for the introductory class had no prior programming experience; most of the balance had only slight experience. When asked why they sign up for the course roughly 60% indicate their intent to use the computer for numeric calculations and statistical analyses; approximately 20% plan to handle large data files; 10% indicate an interest in realtime applications; the balance require graphics displays and text editing. More than half plan to participate in a project currently using ACME; about 20% intend to start a new project.

It is interesting to note that 100% of the participants report that they have access to an ACME typewriter terminal. There are currently 55 terminals in our network.

In addition to the introductory course, ACME staff have prepared and offered seminars and advanced classes. The seminars have dealt with general medical computing topics. A special series of seminars was held concerning time oriented database work.

Some persons learned to use ACME without enrolling in the formal classes. One might estimate that 30% or more of the current users did this. An aid to the persons who preferred to learn by doing is a new program on the public file called "TEACHER". This is a question-and-answer course designed to be used from an alphanumeric CRT terminal.

F. Hardware Changes.

1. Multiplexor.

The satellite machine multiplexor is the most complex and costly equipment item designed and fabricated by the engineering group during FY73. The device, which can connect up to 16 satellite machines to the ACME system, provides a data path to and from the 360/150 in a demand-response mode. Data rates of 40,000 bytes per second are available using 4 twisted pair; rates of 250,000 bytes per second are available using coax. The multiplexor is connected to the IBM hardware through a 16-byte parallel data adaptor on the 2701 which in turn is connected to a selector channel (See Appendix C). Only three computers have been connected through the multiplexor. Additional customers will not be urged to connect until the new 370/158 system and its software become operational.

2. Terminal Controller.

All terminals are connected to the ACME system via a Memorex 1270 terminal controller which was installed in April 1972. This device has performed very well. It has 32 ports capable of automatic speed recognition up to 1200 baud.

3. Standard Analog Interface Card.

A new standard analog card has been developed for use in the laboratory. Since the 1800 is being moved to a distance 2000 feet further from most users, we will be encouraging the user community to convert to digital signals at the laboratory end rather than in the 1800. As a result, the new standard analog card is not likely to be used extensively.

4. Lightbox.

The standard ACME lightbox which has been used on IBM 2741 typewriter terminals was designed to operate off the 2741 power supply. Our shift to G.E. Terminet 300 terminals and Beehive CRT's has made the lightbox unusable. A new one has been designed and will be placed in use in June 1973.

5. Interfaces for Users.

The engineering group has designed and maintained a number of interfaces for user instrumentation. In general these are paid for directly by the customer. Some of the devices interfaced during the past year include scintillation counters, a paper tape reader-punch, and a Houston plotter.

G. Operations.

The annual average meantime between failures due to all causes (hardware, software, power, and human) reached a new high in FY73: 87.7 hours. A chart presenting additional information on meantime between failures is on the following page.

ACME's Operations Manager, Charles Class, spent a great deal of effort on planning support for the 370/158 facility, providing assistance in the areas of hardware, physical space and communications. Here at ACME he was active in the work of installing the new 300 baud terminals.

Mr. Class was the ACME representative in Co-op, an organization formed by the operations managers of the University's service computing facilities to increase communication and cooperation among the several operations groups.

ACME 360/50
COMPARISON OF MEAN TIME BETWEEN FAILURES
JULY 17, 1969 - APRIL 30, 1973
(IN HOURS)

HARDWARE

	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Annual Average
1969-1970:	113.3	55.3	25.2	31.3	56.0	167.3	47.4	39.5	58.7	59.6	83.0	34.5	64.3
1970-1971:	72.4	34.7	176.0	362.0	704.0	104.0	218.7	364.0	182.0	78.2	103.4	176.0	214.8
1971-1972:	244.7	178.0	368.0	39.4	64.2	60.3	56.2	143.8	175.0	42.3	57.8	51.6	123.4
1972-1973:	24.0	58.3	90.3	232.3	72.4	119.8	163.0	181.0	140.0	120.1*	120.1*	120.1*	120.1

ALL FAILURES INCL. HARDWARE

	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Annual Average
1969-1970:	40.0	33.2	17.7	26.5	48.0	44.0	39.0	25.2	27.0	29.8	60.4	22.6	34.4
1970-1971:	29.0	24.3	54.1	181.0	234.7	38.3	54.7	80.9	66.2	37.1	80.4	88.0	80.7
1971-1972:	146.8	142.4	73.6	33.8	54.6	40.2	52.0	79.9	116.7	40.0	39.0	40.2	71.6
1972-1973:	24.0	41.0	80.2	174.2	48.3	55.3	81.5	144.8	140.0	87.7 *	87.7*	87.7*	87.7

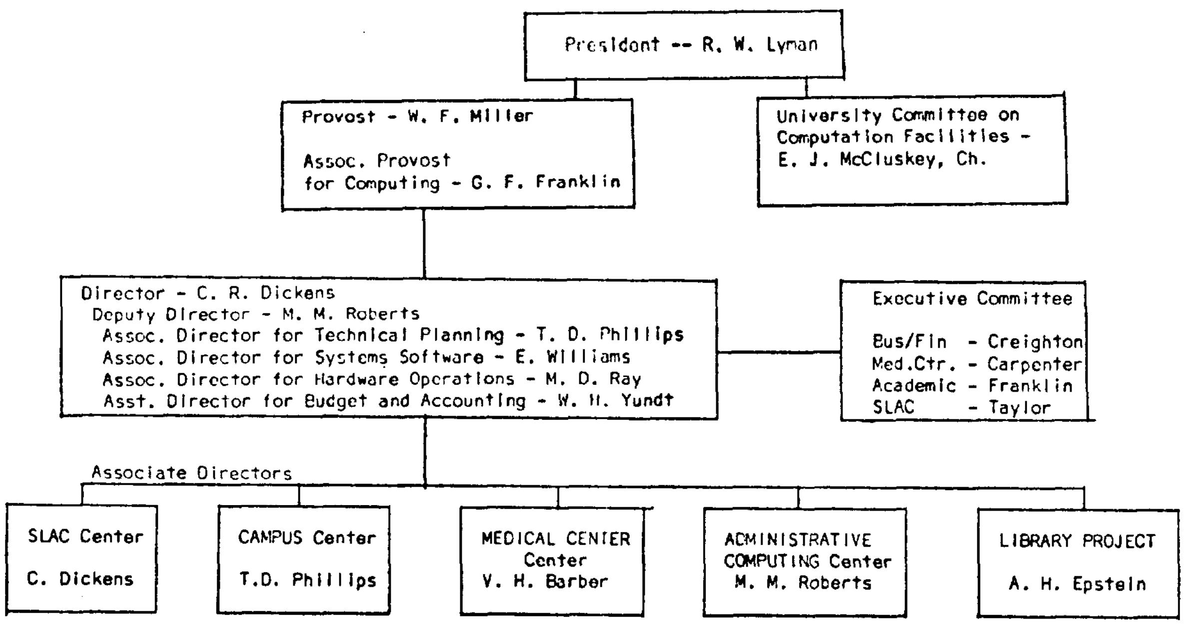
These figures do not reflect failures of 1800, PDP-11, or other systems.

Underlined Figures = Best mean time to failure as compared to same period of each year.

* (May - July, 1973) Projected mean time to failure based upon first nine months, August 1972 through April 1973.

IV. ADMINISTRATIVE ORGANIZATION

The Stanford Center for Information Processing is a new organization for service computing at Stanford University. The SCIP organization is shown schematically below.



STANFORD CENTER FOR INFORMATION PROCESSING

(SCIP)

The ACME computer facility is being merged with the Hospital Data Processing Facility and will now be represented by Mr. Victor Barber as Associate Director of SCIP for Medical Center computing. Until April 1973, the ACME facility was one of three facilities comprising the Computation Center.

The staff of the ACME facility is listed along with the percent of full time equivalent effort on the following page. Major personnel changes which occurred during fiscal year 1973 are as follows:

1. Lee Hundley transferred to the SLAC computing facility where he will be working on realtime applications.

2. Linda Crouse transferred to the Pharmacology Department as a scientific programmer.

3. Rich Cower transferred to the SLAC facility as a computer operator.

4. Jane Whitner and Ying Lew were terminated in view of the end of the ACME grant. The University will consider rehiring them as future needs develop.

5. Chuck Granieri transferred to SLAC as a systems programmer in the spring of 1973.

6. Russell Briggs was assigned full time to the Drug Interaction project.

7. Madeline Aranda, the ACME Secretary, transferred to the Financial Aids Office.

The balance of the staff will likely be assigned either to new computing facilities within the Medical Center or to other service computing facilities on the Stanford campus.

CURRENT ACME PERSONNEL

NAME	% FTE	JOB TITLE
Jamtgaard, R.	100	Director
Wiederhold, G.	40	Consultant
Rindfleisch, T.	100	Systems Analyst
Levinthal, E.	18	Computer Planning Faculty Representative
Frey, R.	100	Systems Programmer
Heathman, M.	60	Systems Programmer
Levitt, R.	50	Systems Programmer
Lipkis, J.	75	Systems Programmer
Miller, S.	100	Systems Programmer
Schroeder, J.	100	Systems Programmer
Stainton, R.	100	Systems Programmer
Williams, E.	50	Associate Director for Systems Software
Bassett, R.	100	Scientific Programmer
Germano, F.	100	Scientific Programmer
Baxter, E.	100	Administrative Asst.
Class, C.	100	Operations Manager
Billger, G.	50	Computer Operator
Sutter, J.	80	Computer Operator
Matous, J.	100	Computer Operator
Rieman, J.	60	Computer Operator
Duffield, A.	80	I.R.L. Support Personnel
Hwang, J.	100	I.R.L. Support Personnel
Pereira, W.	100	I.R.L. Support Personnel
Veizades, N.	100	I.R.L. Support Personnel
Total FTE	19.6	